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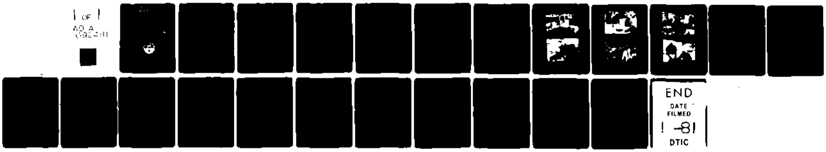

LEVEL IV

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COMPUTER-MANAGED INSTRUCTION IN THE NAVY: I. RESEARCH BACKGROUND AND STATUS

NAVY PERSONNEL RESEARCH AND DEVELOPMENT CENTER
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COMPUTER-MANAGED INSTRUCTION IN THE NAVY: I. RESEARCH BACKGROUND AND STATUS

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FOREWORD

This research and development was performed under Work Unit Z1176-PN-01 (Improving the Navy's Computer-Managed Training System), as part of an R&D project to improve the Navy's operational computer-managed instruction (CMI) system, and was sponsored by the Deputy Chief of Naval Operations (OP-01).

This report, the first of a series on Navy CMI, describes the problem areas that limit the effectiveness of the CMI system and the R&D proposals that have been developed to address these problems. Future reports will describe work being done under these proposals. Results will be used by the Chief of Naval Education and Training (CNET), Chief of Naval Technical Training (CNTT), commanding officers of all the Navy CMI schools, and others concerned with computer-based instruction.

Appreciation is extended to Mr. Dwain Chambers (CNTT Code N-824) (CMI system manager), the staff and students at all of the technical training schools on the CMI system, and the Service School Command, San Diego, for their assistance during the project. Also, appreciation is extended to Dr. H. S. Pennypacker, Jr., University of Florida, Gainesville, for the consulting service he provided during the problem analysis and initial R&D phases.

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SUMMARY

Background

The Navy is currently operating a computer-managed instruction (CMI) system involving approximately 9000 students a day in 10 technical training schools. As the system adds students, courses, and capabilities, a coordinated R&D effort is required to ensure the most cost-effective and productive technical training system.

Objectives

The objectives of this project were to identify the problem areas that limit the effectiveness of the CMI system and to develop coordinated R&D plans to solve problems amenable to research solutions.

Approach

Major system problems were identified and suitable research proposals were developed through a four-phase effort:

Phase I. Problems were identified by observing the system and by administering questionnaires to and holding structured interviews with CMI management, instruction staff, and student personnel.

Phase II. Other computer-based instruction systems, both civilian and military, were examined to identify analogous problems and solutions.

Phase III. Candidate research proposals were developed to support the major problem areas identified.

Phase IV. Members of the research and operational technical training communities assessed the proposed research plans in terms of (1) importance of the problem involved, (2) feasibility of the proposed research, (3) research and human resources requirements, and (4) expected costs and benefits of applying the product of the R&D.

Results

The following six R&D proposals were given the highest priority by CNTT and CNET, and form the basis of NAVPERSRANDCEN's initial CMI R&D effort:

1. Effects of incentive charts on rate of progress through a CMI course.

2. Instructor role in a CMI environment.

3. Computer-generated reports for the management of student learning.

4. Development and incorporation of automated performance tests into the CMI system.

5. Development of alternate test strategies to improve mastery and retention in selected CMI courses.

6. Development of computer software to aid data summarization for research and management analysis.

CONTENTS

INTRODUCTION

Problem and Background

Development of the Navy CMI System

Since the 1960s, the Navy Personnel Research and Development Center (NAVPERSRANDCEN) and its antecedent laboratories have been working with operational Navy training commands to develop cost-effective, computer-based training systems for large-scale operational training. In 1968, the Naval Personnel and Training Research Laboratory, San Diego (NPTRL) and the Chief of Naval Air Technical Training (CNATECHTRA) formally entered into an advanced development project to develop a computer-managed instruction (CMI) system. During 1972, the first course--Aviation Fundamentals--was officially conducted with the prototype system developed under this project. In 1974, CNATECHTRA and the Chief of Naval Education and Training (CNET) adopted CMI as a formal component of the Navy training system. In 1975, the Navy Education Training and Instructional Systems Activity (NETISA) (now the Management Information and Instructional Systems Activity (MIISA)) let a contract for automated data processing (ADP) hardware and software services for the existing system. Since that time, CNET and the Chief of Naval Technical Training (CNTT), with NAVPERSRANDCEN support, have worked to develop courses and expand the CMI system. A comprehensive R&D project is needed to support the Navy CMI system as it expands in size and capabilities.

Physical Characteristics of the Navy CMI System

The Navy CMI system is one of the largest computer-based instruction systems in existence. This system, using off-line, individualized instruction materials, currently manages the daily instruction progress of about 9000 students in 10 technical training schools at 5 locations: Millington, TN; Orlando, FL; Great Lakes, IL; San Diego, CA; and Pensacola, FL. These schools teach the following courses: Basic Electricity and Electronics, Radioman "A," Propulsion Engineering Basics, Aviation Fundamentals, Aviation Mechanics, Avionics "A," and a portion of the Electronic Warfare Fundamentals course. The central computer facility for the system, which is located at MIISA, Millington, TN, grades tests, does record keeping, assigns study instructions, and provides information to instructors, school directors, and the CMI system manager (ranging from data about individual students to summaries of system effectiveness). The CMI system will eventually expand to a projected capacity of about 15,000 students in 25 schools in 6 locations. When fully operational, the system will be responsible for the instruction management of nearly 30 percent of all the students in Navy technical training.

Although the physical layout of the learning centers (LCs) in the Navy CMI system varies from school to school, the same components are present in all centers. Generally, each LC consists of a room with rows of individual study carrels. Areas for the distribution of instruction materials and equipment are located near each LC. Achievement testing of the knowledge or theory portion of the course may occur at either the student carrels or in a designated test area. In both cases, after the test is completed, the student submits a machine-scorable answer sheet into an optical scanner (OPSCAN Model 17), and a teletypewriter printer (GE Terminet Model 1200) provides feedback to the student in the form of a Learning Guide. In some CMI schools, special areas are set up for testing specific performance skills. For example, the students may troubleshoot equipment or components that have been prefaulted. One instructor in each LC is responsible for 25 to 30 students, who may seek assistance at any time throughout the training day. The total training day is 8 hours, with 6 hours typically spent in CMI instruction and 2 hours in other military training. To accommodate large numbers of

students, some schools may operate two or even three consecutive shifts of trainees a day, obtaining maximum benefit from the physical plant and staff. Since individual instruction is given, and students work at varying paces, study continues during the entire 6-hour shift. Students take breaks at their own discretion.

Figures 1a through 1f illustrate a typical Navy CMI LC at the Basic Electricity and Electronics School, San Diego.

The CMI Instruction Process

Navy CMI focuses on student interactions with the curriculum materials (including text matter and equipment), the instructor, and the computer system. Figure 2 shows the possible interactions of system components during the instruction process.

A student may begin the CMI course at any time, receiving a module study assignment to be worked at a self-determined pace. Each module generally takes 2 to 5 hours to complete. The student interacts with the curriculum materials by selecting and studying the various instruction media or pieces of equipment. Although most instruction material is printed text, sound slides and other media are also used. Students take a "progress check" test (usually self-scored) to determine whether they have mastered the lesson materials before they take the final module test.

When the students feel that they have mastered all objectives for the module, they take a module knowledge test from a test center. Responses are entered on a machine-readable answer sheet, which is inserted into an optical scanner. Responses are then processed by the scanner and transmitted on leased telephone lines to the central computer at Millington, TN. Within 30-60 seconds, the computer identifies the student and the test, scores the test, stores responses in a student history file, determines the next assignment, and transmits test results and the next assignment back to the student. A typewritten Learning Guide, obtained from the printer near the scanner (Figure 1c), indicates missed questions, lists lessons or objectives needing additional study, and informs the student of remediation tests that he must complete after such study. After the student has mastered all module objectives, the next module is assigned.

On the existing CMI system, the instructor transmits performance test responses to the computer by completing a check sheet and making an administrative entry. A more automated procedure is currently being followed at the Radioman "A" school, where automated teletyping performance testing has been developed. Here, a direct connection between the student response (teletypewriter keyboard performance) and the computer provides automatic evaluation of student performance.

Students interact with the instructor for a variety of reasons. For example, they may ask questions about course subject matter, request additional materials, interact for personal reasons (e.g., problems in or out of school that affect progress), or simply request confirmation of their progress. To interact well with students, instructors must have technical competence, teaching ability, and interpersonal counselling skills. They must handle administrative and subject-matter queries, know the instruction materials and equipment, and be able to interpret and use the student progress information available from the computer and school. This computerized progress information comes from a Student Response History file, which includes individual student records, or from a daily Learning Roster, which indicates the current state of the instructional progress of all students in the instructor's LC. The roster tells the instructor what modules students are studying, how long they have been assigned specific modules, and, most important, how the actual instructional progress of each student compares with his predicted progress, based

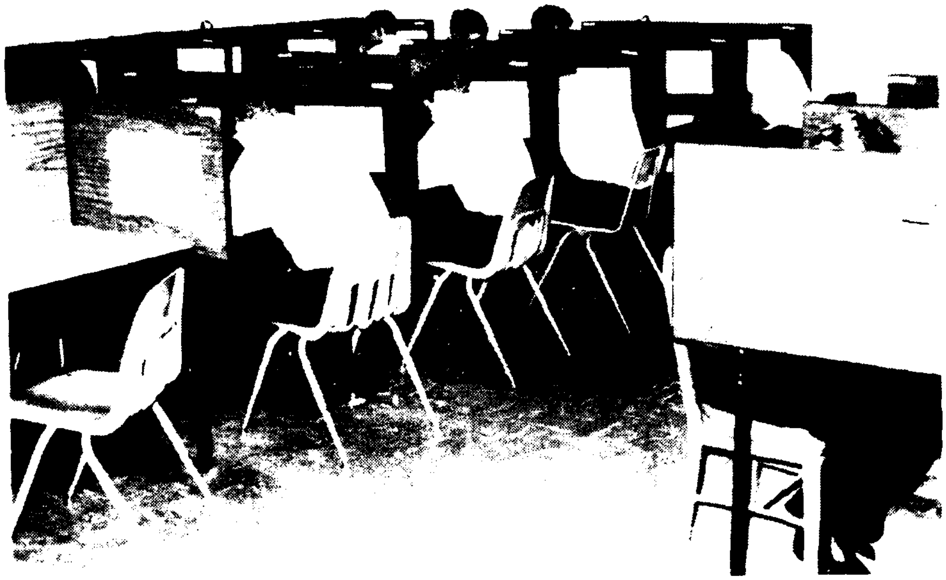

Figure 1a. Navy technical training students studying in a CMI Learning Center.

Figure 1b. CMI students study instruction material, tests, and actual equipment at individual study carrels.

Figure 1. Views [illegible] CMI Learning Center.

Figure 1c. At the CMI equipment cluster, the student on the right is tearing off his test results from the printer after entering the test answer sheet into the optical scanner in the foreground.

Figure 1d. An area is set up where students complete skill-performance tests using real equipment.

Figure 1. (Continued).

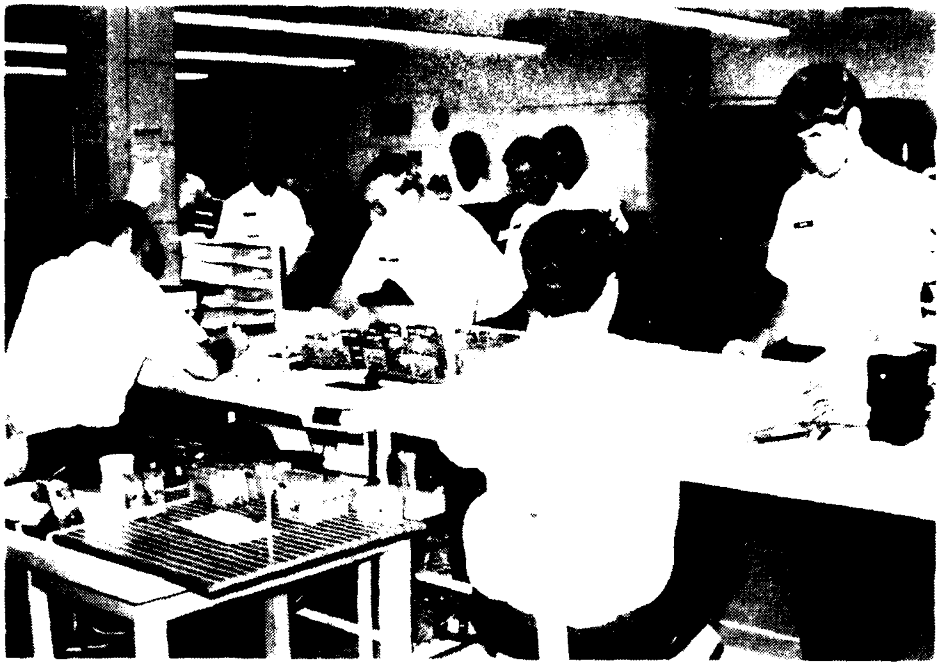

Figure 1e. CMI students may check out prefaulted equipment or modules at a central performance-test area where test scoring is also performed.

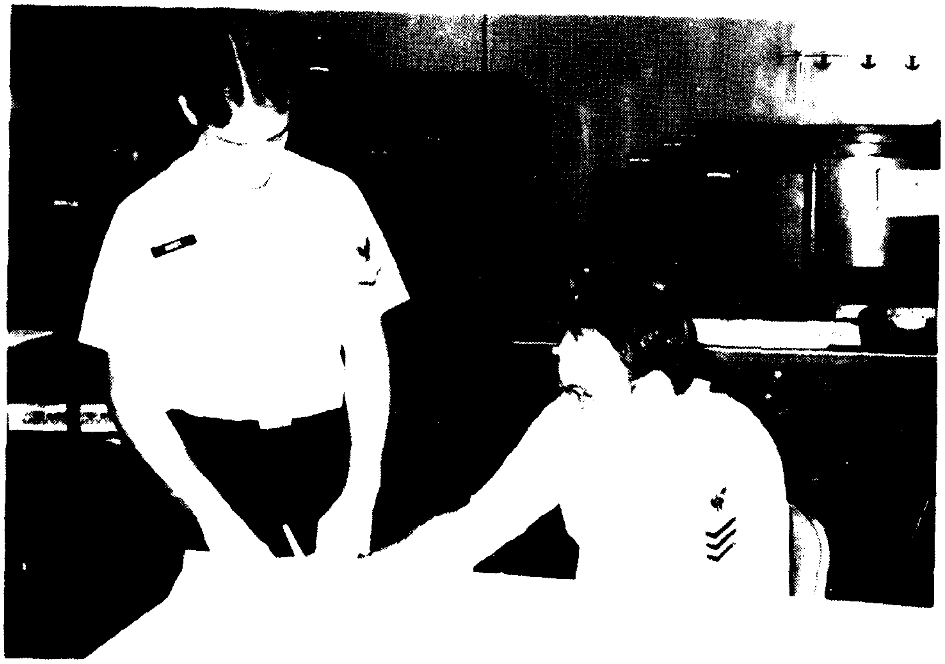

Figure 1f. Students may receive assistance from their Learning Center instructors at any time during the instructional day.

Figure 1. (Continued).

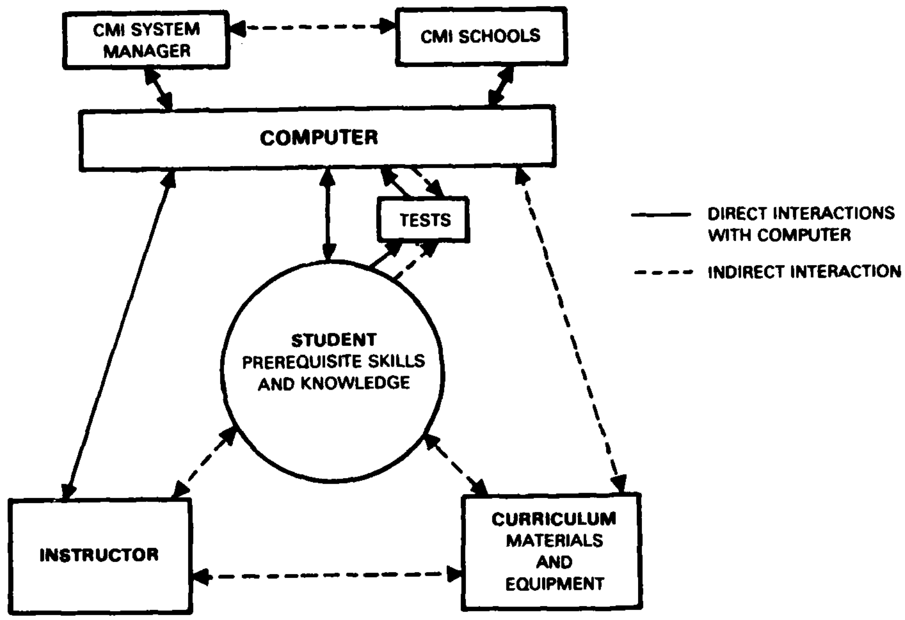

Figure 2. A diagram of the relation of components of the Navy CMI system.

on his Armed Services Vocational Aptitude Battery (ASVAB) test scores, age, and school records. Ideally, this actual versus predicted student progress information would enable the instructor to take the corrective action needed to assure satisfactory progress of every student through the course. Although self-pacing occurs through the instructional materials, it is expected that the student will maintain a study rate that will result in course completion within the predicted time, and that the instructor will assist the student in maintaining a minimum predicted rate of progress. These instruction progress expectations minimize training time and facilitate timely assignment of school graduates to follow-on schools or fleet billets.

Despite the current success of the system in managing student progress, projected expansion dictates the following questions:

1. Can improved instruction interactions bring more cost-effective training?

2. Can the system expand in size and capability without excessive cost growth?

3. Can improvements in Navy CMI apply to other services and to industry and academia?

Objectives

The objectives of this effort were to identify the problem areas that limit the effectiveness of the CMI system and to develop coordinated R&D to solve problems that are amenable to research solutions.

APPROACH

The project commenced in 1977 and was conducted in the following four phases:

1. Identification of CMI system problems and requirements.
2. Review of other CMI systems.
3. Development of candidate R&D proposals.
4. Setting R&D priorities.

These phases are described in the following paragraphs.

Phase I--Identification of CMI System Problems

The CMI system manager (CNTT Code N-824) is responsible for maintaining an operational training system for thousands of students. Since the system manager is the focal point for complaints on system problems, he was able to identify a number of problems that he felt might be amenable to an R&D solution. Other CNTT staff members, representing training-program coordinators and CNTT research organization, were asked to give their perception of CMI problems.

User perceptions of CMI problems were obtained by administering questionnaires on system effectiveness to the students, instructors, and training officers at the eight schools then on the CMI system. All elements of the CMI process and the procedures followed by the training schools were examined. Results showed that user perceptions of problems were consistent with those of the CNTT staff. These problems were primarily related to the interactions of system components--the student, the curriculum, the instructor--and to the requirement to maintain a flow of properly trained students from course to course and out to the fleet.

Thirteen specific problem areas were identified and classified into three general categories: (1) physical and environmental constraints, (2) student and system deficiencies, and (3) system capability limitations. Problems in physical and environmental constraints were most easily observed, but were not usually correctable by research. For example, repair of defective heating and cooling systems does not call for R&D.

The second category--student and system deficiencies--was characterized by unique problems students meet as they progress through the course. These difficulties stem from inadequate direction by either the computer or instructor, or result from problems met in mastering the course materials or tests.

The third general class of problems concerned the CMI system's limitations. For example, the computer system could not adequately maintain a student's step-by-step progress record that was easily retrievable. Thus, if the student had difficulty in latter stages of the course, suitable records of past progress were not readily available to assist in assigning remedial instruction. Failure to provide adequate learning within a course is most serious when a student who has completed the CMI course cannot demonstrate, during a follow-on course or the on-the-job, skills he is supposed to have acquired.

Phase II--Review of Other CMI Systems

In the second phase, large-scale CMI training systems maintained by the other military services, industry, and academia were reviewed to identify possible solutions for the types of problems identified in the Navy CMI system. A comprehensive review of all computer-based systems was not attempted. Rather, the review focused on those systems designed to manage large numbers of students through individual instruction materials.

Systems selected for review included the Advanced Instructional System (AIS), at Lowry Air Force Base, CO; the Computerized Training System (CTS) at Fort Gordon, GA; and civilian systems at the Universities of Illinois, Pittsburgh, California at Irvine, and Florida. Results of the reviews showed that virtually all of these systems experienced similar problems. Solutions were not directly available and would have to be tailored to specific systems. The Navy system, it was noted, was more advanced in some operational respects than many of the non-Navy systems. Certainly, the goals of military training made the Navy system more capable than non-Navy systems in predicting student progress--despite the problems associated with this feature of Navy CMI.

Phase III--Development of Candidate R&D Proposals

In the third phase, NAVPERSRANDCEN researchers and consultants, with input from the schools and management organizations, developed candidate R&D proposals in support of the 13 problem areas identified in Phase I. These plans, which are listed below, described the problem, the proposed research approach, and expected costs and benefits should the research be successful.

1. Expanding strategies and tactics for remediation in the Navy CMI system.

2. Evaluating and monitoring knowledge and skill retention within and beyond the Navy CMI system.

3. Development and application of student perception and motivation reports.

4. Effects of incentive charts on rate of progress through a CMI course.

5. Study management-system implementation in an existing course of instruction.

6. Instructor role in a CMI environment.

7. The allocation of instructors in a CMI environment.

8. Descriptive and predictive measurement of performance in the Navy CMI systems.

9. Computer-generated aids for the management of student learning.

10. Development and incorporation of automated performance testing into the CMI system.

11. Effect of test-item response characteristics on mastery and retention in selected CMI courses.

12. Opportunities for software improvements in the Navy CMI system.

13. Exploiting computer technology to improve computer-based instructional management.

Phase IV--Setting R&D Priorities

In the fourth phase, military and civilian researchers and members of the operational training and management organizations met to discuss the severity of the problems, feasibility of the proposed research solution, availability of research and human resources,

and costs and benefits of the solutions. After each proposal was presented and discussed, participants completed an open-ended questionnaire to provide a summary of opinions. An abstract of each proposal and a consensus on the importance of each are provided in the appendix.

After all 13 proposals had been discussed, a final period was devoted to omissions, priorities, and the sequencing of the various R&D elements. One omission was identified: the development of a resource-allocation system to facilitate the assignment of students and instructors to study carrels, study materials, test equipment, test settings, and learning centers. It was suggested that a program was needed to determine how to get maximum value from minimum resources. Development of this resource-allocation system was judged to be an operational rather than a research issue.

RESULTS

CMI Research Priorities

The CNTT staff assigned priority to five R&D proposals that warranted immediate attention. CNET (Code N-5) endorsed CNTT's priorities and added another proposal to the list. Therefore, NAVPERSRANDCEN's initial CMI research was directed toward the following six proposals:

1. Effects of incentive charts on rate of progress through a CMI course.

2. Instructor role in a CMI environment.

3. Computer-generated aids for the management of student learning.

4. Development and incorporation of automated performance testing into the CMI system.

5. Development of alternate test strategies to improve mastery and retention in selected CMI courses (modification of Plan #11).

6. Development of computer software improvements to aid data summaries for research and management analysis (modification of Plan #12).

Initial Research Efforts

This section describes the initial research efforts conducted on the six R&D proposals receiving priority status.

Effects of Incentive Charts on Rate of Progress Through a CMI Course

Since student motivation is a fundamental problem in CMI, some kind of incentive system is needed to prod students into continuous activity. In this program, incentive charts were used to record progress made, encourage study, and reduce training time.

The incentive chart experiment was conducted at the BE&E "A" school, Millington, TN, using a NAVPERSRANDCEN IBM 5110 computer and civilian researchers. The results demonstrated a significant decrease in training time. The experimental group, which received the computer-generated incentive charts on request, completed the course in 95 hours, compared to 103 hours for the "no chart" control group.

If the procedures work as well with the operational CMI equipment and Navy personnel as they did in the experimental test, the system can be used at CMI schools by merely "turning on" the charts. An operational test is planned with Navy instructors, multiple schools, and the Navy's central computer system. This project is an example of an R&D effort that has the potential to yield significant benefits with little implementation costs. If the experiment results are repeated, a full training day per student could be saved with a cost avoidance of over $1 million annually.

Instructor Role in a CMI Environment

A contract has been let to McDonnell-Douglas, Inc. to develop the ideal CMI instructor role-model for the Navy, Air Force, and a proposed Marine Corps CMI systems. Because of its cross-service application, this research was funded jointly by NAVPERSRANDCEN and the Advanced Research Projects Agency. The functions defined for the instruction will be validated empirically in the Navy CMI system. Results of this project are expected to be available for the instructor training course being developed by the Naval Education and Training Support Center, Norfolk.

This research represents the first attempt to develop a CMI instructor role from a theoretical perspective followed by an empirical validation. Results from this research will impact on virtually every existing military and civilian CMI system. Completion of the work is expected in FY 1981.

Computer-Generated Aids for the Management of Student Learning

Work in this area has focused on improving the system's capability to predict a student's completion time. Although the system now predicts total course completion time fairly accurately, the prediction times for completion of individual modules must be improved. Work on prediction capability has focused on the BE&E course.

Development and Incorporation of Automated Performance Testing into the CMI System

This completed effort improved the efficiency of performance-skill training by using CMI to score and analyze performance tests automatically. Teletyping instruction in the Radioman "A" school at San Diego was chosen for this study because manual scoring procedures were tedious, time consuming, and subject to errors. Some instructors spent all day manually scoring typing tests. Personnel from the computer and instructional development organizations--the Management Information and Instructional Systems Activity (MIISA), and the Instructional Program Development Center (IPDC), San Diego, with support from NAVPERSRANDCEN, developed a system for automated testing of teletyping performance; NAVPERSRANDCEN developed a system for providing diagnostic feedback to the student on the types of errors being made. With automated testing procedures, the average time required for students to complete a typical three-test series was cut from 40 minutes to 24 minutes. More importantly, the new system reduced typing-course completion time and student attrition rates. These savings are attributed to the Error Distribution Report (EDR) provided by the new system, which gives the student detailed information on areas where improvement is needed. During the research, a daily EDR reduced course completion time from an average of 85 hours to 64 hours, a savings of almost 3 full training days. The EDR also helped reduce attrition rates from 25 to 10 percent in the experimental samples. The automated testing system and resulting EDRs are now in regular use at the Radioman school.

Development of Alternate Test Strategies to Improve Mastery and Retention in CMI Courses

This research is concerned with determining the types of knowledge test items and testing procedures that are appropriate for technical training under computer management. At present, the CMI system is limited to using multiple-choice questions. Answers tc these test items are fed into an optical scanner via paper answer sheet. Costs for answer sheets and optical scanners are very high. While the multiple-choice testing format is convenient for machine scoring, its exclusive use may not result in the necessary level of mastery, since it is simply a measure of recognition. In developing instructions, fill-in questions for testing recall of material must be used to satisfy certain types of training objectives.

In response to such criticisms, the Propulsion Engineering (PE) school, Great Lakes, developed a method of converting fill-in item responses to a modified multiple-choice format that permitted machine scoring. This conversion procedure, however, may have decreased test accuracy and increased course completion time. During the research, NAVPERSRANDCEN found that answer conversion did not decrease test scoring accuracy appreciably, but did require an average of an extra half day of training in a 22-day course. While all question types resulted in similar end-of-course achievement, fill-in questions without cues resulted in better 2-week retention.

Current work on alternate test strategies involves implementing some of these findings by eliminating the optical scanners and paper answer sheets. This approach would reduce operating costs while improving the instructional capabilities of the system.

Development of Computer Software Improvements to Aid Data Summaries for Research and Management Analysis

This work has involved software to improve the system's management and research capabilities. The system must improve its ability to use massive amounts of data used to track students and evaluate instructional materials and system effectiveness.

Numerous improvements have already been made in the system's ability to summarize individual student, group, and other data to facilitate changes in manuals or procedures. The data summaries are available to school, management, or research organizations and have been applied by CNTT and MIISA to the operational system.

Future Research Issues

Since the Navy CMI system has matured since the initial research priorities were set, and since part of the original R&D has been completed, the operational training organization priorities have shifted to meet current concerns.

A CMI study conducted during the problem analysis compared alternate student to instructor (S/I) ratios in a CMI LC at the BE&E school, San Diego. The study investigated whether student performance would suffer if the S/I ratio were increased. The results suggested that, although the increased S/I ratio did not result in performance decrements, training time increased in some career paths. The data revealed that the role of the instructor most definitely affects student performance, and suggested that altered instructor duties may ultimately lead to more cost-effective training.

From the S/I ratio study, it was apparent that a more comprehensive investigation was needed to determine the most cost-effective ratio. Further investigation should

involve different courses, larger sample sizes, a wider range of S/I ratios, and other variables, since different courses and schools will undoubtedly make different demands on their instructors.

From the test item study performed at the PE school, two research topics have emerged: (1) planning and evaluation of a test-answer input device (TID) that would replace the optical scanner and the paper answer sheets, and (2) development of proper CMI testing and remediation strategies (an extension of current research).

In addition to research essential to improving current CMI systems, planning for a future-generation Navy computer-based training system is needed. It is obvious that this planning must begin soon, even if a major system change is not to occur for several years. This planning must include the economic analysis suggested by Orlansky and String[1] to ensure development of a more cost effective system. It is only by pressing the research questions and the available instructional technology that the CMI system can continue to handle its full share of the Navy training responsibility.

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[1]Orlansky, J., & String, J. Cost-effectiveness of computer-based instruction in military training (IDA Paper P-1375). Arlington, VA: Institute for Defense Analyses, 1979.

APPENDIX

**CANDIDATAE CMI R&D PROPOSALS:
ABSTRACTS AND PLANNING SESSION CONSENSUS**

CANDIDATE CMI R&D PROPOSALS: ABSTRACTS AND PLANNING SESSION CONSENSUS

This appendix presents abstracts of the 13 candidate research proposals developed during the CMI R&D Planning Session, along with a participant consensus of the importance of each plan. Order of presentation does not imply order of importance.

1. Expanding Strategies and Tactics for Remediation in the Navy CMI System

Abstract. This project considers the development of remediation approaches applicable to the CMI system to improve basic skills of trainees, remedy skill deficiencies within a course of instruction, or remedy technical skill deficiencies that occur across a sequence of CMI courses.

Consensus. Although remediation of basic skill deficiencies is important, techniques to help acquire technical skills have even higher priority. Research should focus on the identification and use of remediation techniques that are the greatest aid to learning. Appropriate remediation techniques would simplify control of student learning progress during a course and would aid the development of individualized CMI course materials.

2. Evaluating and Monitoring Knowledge and Skill Retention Within and Beyond the Navy CMI System

Abstract. The intent of this project is to determine how long students retain the knowledge and skills taught in the CMI courses. Their ability to retain knowledge will be assessed after they have begun work in the fleet or just before or during follow-on training courses. Assessing knowledge and skill retention during a follow-on training course will be aided by computer-managed testing programs that reflect the course-model sequencing and structure of the original course. Intracourse retention would be determined through similar computerized testing and an off-line assessment procedure.

Consensus. The quantification of the retention problem is of great importance to the Navy, but must be handled appropriately to ensure comparison with proper baseline data when determining the extent of the problem in both CMI and non-CMI learning situations. Extensive system design effort may be needed for proper measurement of retention along with "fleet enthusiasm" for post-training assessment. The product of this R&D effort would have tangible residual benefits for operational training, since the programming would remain in the computer system itself.

3. Development and Application of Student Perception and Motivation Reports

Abstract. The purposes of this project are to develop automated techniques for determining student perceptions of the instructional environment and to assess student motivation. The automated student critiques would enable schools and training management to obtain summarized data, routinely, on levels of student motivation and on student opinions of the quality of instruction.

Consensus. There is need for a service-wide effort that would facilitate the systematic collection of subjective data from the students about their school experiences. It should be possible to relate these data to changes made in the school. Use of student time in the administration of the critiques should be minimized, however, and the automated critiques should focus on benefits to the school and not on the acquisition of basic research data.

4. Effects of Incentive Charts on Rate of Progress Through a CMI Course

Abstract. This R&D involves development of graphic displays of student progress in a CMI course as an incentive to study. Other incentives to study would be devised by school management to reinforce the motivation provided by the displays.

Consensus. This project is of sound design and important for the proper management of a CMI system. The effort would yield an additional and innovative means of measuring and motivating study progress. R&D costs would be low. System-wide cost could be estimated fairly accurately following the research effort. Previous research indicates that payoff from this R&D effort would be high.

5. Study-Management System Implementation in an Existing Course of Instruction

Abstract. Computer-managed study techniques, developed in prior research efforts, would be implemented in an existing lecture-based course. The R&D intent would be to determine the feasibility of a low-cost method for individualizing a course focusing on Navy schools that are not presently scheduled for full-scale instructional development.

Consensus. This project serves the clearly worthwhile function of developing cost-effective methods for individualizing additional courses into a CMI system. Selection of the course and careful course analyses and development are extremely critical to this effort. Accurate documentation of implementation activities and costs is necessary to derive maximum benefit from the R&D effort.

6. Instructor Role in a CMI Environment

Abstract. This project broadly describes the R&D necessary to determine the instructor's role in CMI. Specifically, the proposal calls for the specification of CMI instructor activities, development of an interim in-service training program for immediate use in CMI schools, and development of a formal training program for candidate instructors. A critical aspect of this proposal is the accurate specification of the instructor's role so instructor aids from other R&D efforts can be exploited.

Consensus. Development of an instructor training program that accurately reflects the instructor duties in a CMI school is very important for a large operational computer-based training system. It is clear that research is needed for proper instructor role definition, since the majority of previous research has dealt with instructors in a lecture-based school environment. A vitally important aspect of the research is the proper use of instructor evaluation measures. Measures of instructor-effectiveness should reflect not only direct observation of instructor activities, but also the degree of student success. This research is particularly important in view of the limitations placed on initial selection of individuals for instructor duty. This project should be broadened to include the development of a training program for CMI school managers.

7. Allocation of Instructors in a Computer-Managed Instructional Environment

Abstract. This project will determine the best CMI student-to-instructor ratio and learning-center configuration. It seeks to determine the ratio bandwidth through which managerial perrogatives can vary before cost or benefit thresholds are exceeded.

Consensus. It is important to establish the S/I bandwidth so that management can make decisions on manning, but it is also necessary to consider the types of activities

assigned to instructors in the learning center. This research must be coordinated with Proposal 6, which involves overall instructor training.

8. Descriptive and Predictive Measurement of Performance in the Navy CMI Systems

Abstract. This project involves the development, test, and application of a technique, using test-response latency, to measure the student's mastery of course material. Data on how long students take to master segments of a course can be recorded during actual training. These data can be built into the computer to aid predictions if it is determined that the benefits will justify the cost.

Consensus. This project will develop more sensitive measurement of mastery in a CMI course. Time is certainly one of the achievement variables. Although there is minimum R&D effort, the cost of applying the results of the R&D to the actual operating system may not be justified by the benefits. Cost-effectiveness must be determined by accurate estimates during the research phase. The use of response latencies in measuring performance is important, since the measure of 100 percent mastery based solely on number of correct test items is too insensitive for use in an operational training system.

9. Computer-Generated Aids for the Measurement of Student Learning

Abstract. This project examines the daily progress reports instructors receive in the CMI learning center. Both the predictive capabilities of the regression equations used in estimating student progress and the format for displaying information to the instructor require improvements.

Consensus. This project has high priority because of an existing problem in all Navy CMI schools. Consideration should be given to expanding the project to include improvement of the data displays for the school and system managers.

10. Development and Incorporation of Automated Performance Testing into Computer-Managed Instruction

Abstract. This project is intended to identify, automate, and incorporate in the CMI system those performance skill-testing activities that would result in more cost-effective training and more accurate performance measurement. The initial effort in this project involves the automation of teletypewriter-keyboard performance testing in the RM "A" school at San Diego. The R&D will emphasize techniques that will facilitate automated CMI performance testing and will accelerate skill acquisition.

Consensus. While the general issue of identifying skills and automating their performance testing on a CMI system is important and has high priority, care should be taken in the case of the RM school not to redo extensive typing training research.

11. Effect of Test-Item Response Characteristics on Mastery and Retention in Selected Computer-Managed Courses

Abstract. This project will determine test-item formats compatible with CMI that provide maximum instruction and measurement benefits. This research will examine the test response characteristics, along with other test item formats, currently in question at the Propulsion Engineering School at Great Lakes. The validity of each test response procedure will be assessed against an independent performance test.

Consensus. Because the proposal addresses a broad and recurring problem in the existing test system used with Navy CMI, the R&D effort should move beyond the limitations imposed by simple 5-alternative multiple-choice questions. The proposal will apply to all CMI schools, although the focus is on test response characteristics for immediate use. Clearly, the validity of any of the response formats should be carefully determined for the particular subject matter being taught. This project may well be the source of some of the most practical innovations to enrich and extend the existing Navy CMI system.

12. Opportunities for Software Improvements to the Navy CMI System

Abstract. This project is designed to determine fully the users and uses of the data available on the Navy CMI system. The data use determination would focus on those uses that could be exploited by the existing computer system in the near future. Users would include not only the personnel from the schools (students, instructors, and managers), but also the training system managers, computer scientists, and research personnel. Identified data uses would be refined and arranged in priorities with NETISA, the activity responsible for system analysis and programming.

Consensus. This R&D effort will be useful to school, management, and research personnel; successful completion is a necessary step toward full-scale use of the results of other research. The project is clearly related to data-management problems currently experienced by the Navy and other CMI systems, and will be of real benefit at little cost. NETISA personnel should be intimately involved with this effort from the outset to maximize system benefits.

13. Exploiting Computer Technology to Improve Computer-Based Instruction Management

Abstract. This R&D will determine the configuration of a second-generation computer system for Navy CMI.

Consensus. This effort is a necessary R&D activity that will facilitate future operational decisions. While the effort is very worthwhile, experimental approaches besides the Delphi technique might be considered. R&D resources will be required, and the Navy will benefit greatly, although the benefit will be evident only when the planning for a subsequent computer configuration is initiated. A secondary benefit will be the establishment of a precedent and procedure for long-range planning in the broad area of military technical training.

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